Palatine, Illinois

Phase II

Hydrogeologic Investigation of Rodale Manufacturing Site Emmaus, Pennsylvania

November 1989

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WESTON SM
MANAGERS DESIGNERS/CONSULTANTS

SQUARE D COMPANY

PHASE II REPORT

HYDROGEOLOGIC INVESTIGATION OF THE RODALE MANUFACTURING SITE, EMMAUS PENNSYLVANIA

(b) (4) [redacted]
Project Director

(b) (4) [redacted]
Project Manager

(b) (4) [redacted]
Project Geologist

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Prepared By:

Roy F. Weston, Inc.
Weston Way
West Chester, Pennsylvania 19380

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SECTION 1

INTRODUCTION

Roy F. Weston, Inc. (WESTON) has been retained by the Square D Company to investigate and remediate the existing ground water contamination at the former site of Rodale Manufacturing Facility (Rodale) in Emmaus, Pennsylvania. The Phase I of this project was a review of Square D Company's files and reports concerning this site. This report describes the findings of Phase II of this project, which was to accomplish the following:

- Fracture trace analysis.
- Inventory of water discharge points and water wells.
- Historical aerial photographic survey.
- Recommendation of additional field investigations to define the extent of ground water contamination.

Background and current information was obtained from the following sources:

- State and municipal files
- Well records
- SNR Company Ground Water Monitoring Plan for the site
- Various areas-specific geologic reports
- Personal communications
- Examination of aerial photographs.

The report contents are divided into nine sections that discuss the topics investigated during this study.

- Section 1 - Introduction
- Section 2 - Geology
- Section 3 - Hydrogeology
- Section 4 - Inventory of Water Discharge Points and Water Supply Wells

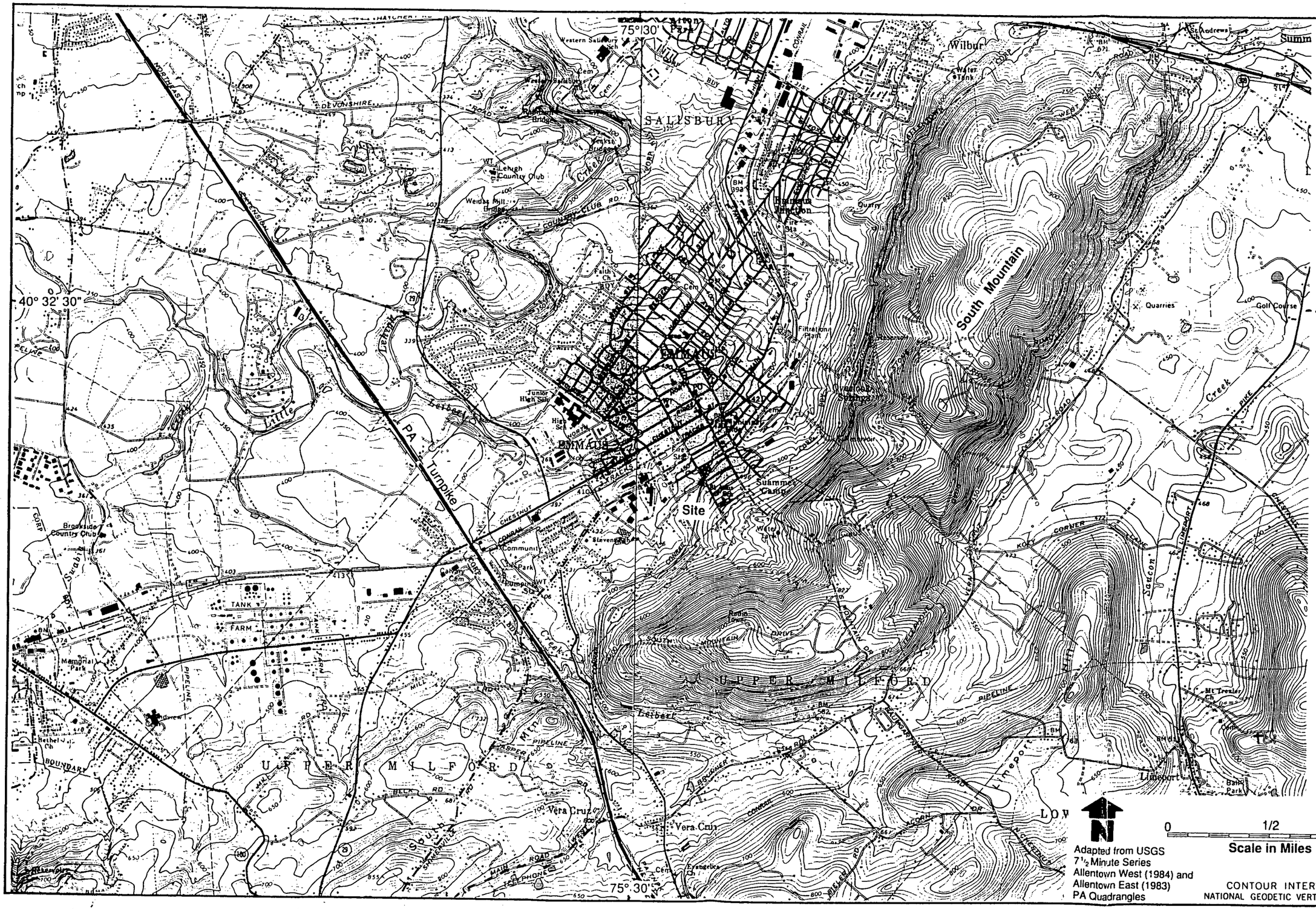

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FIGURE 1-1 REGIONAL MAP

SECTION 2

GEOLOGY

The site is located on carbonate rocks of the Great Valley Section that are northwest of the older clastic and crystalline rocks of the Reading Prong (Figure 2-1). The carbonate rocks of the Great Valley Section which are in the area of the site are the Allentown and Leithsville Formations (Kochanov, 1989). The Leithsville Formation underlies the site and the Allentown Formation lies in the down slope area located to the northwest of the site. The Leithsville Formation is primarily a dolomitic limestone and sericitic, limy shale (Wood et al., 1972). The Allentown Formation is a dolomite with interbedded limestone (Wood et al., 1972). Karstic features, such as sinkholes, are typical features of both of these formations.

The Reading Prong is represented by South Mountain and is characterized by three types of clastic and crystalline bedrock: gneiss, granite, and the Hardyston formation, a quartzite and quartz pebble conglomerate (Wood et al., 1972). Except possibly as a source of some ground water, the rocks of South Mountain are unrelated to the site.

The rocks of the Emmaus region generally strike northeast to southwest and have a southeast dip (R.E. Wright Assoc., 1982). The identified faults closest to the site are those in the older clastic and crystalline rocks of South Mountain (Figure 2-1). The extent of the faults in the carbonates is not known and the lateral displacement, if any, appears to be small.

The deformation, which resulted in the joints and fractures of the carbonate rocks, was related to thrust faulting and regional folding (R.E. Wright Assoc., 1982). The deformation was intense, as evidenced by the erratic changes in strike and dip (Figure 2-1). At location A in Figure 2-1, the strike of the bedrock remains the same, but the dip of the bedrock changes from 5° North to 30° South over a distance of about 500 feet. Generally, the jointing is better developed along the crests of anticlines in the region (R.E. Wright Assoc., 1982).

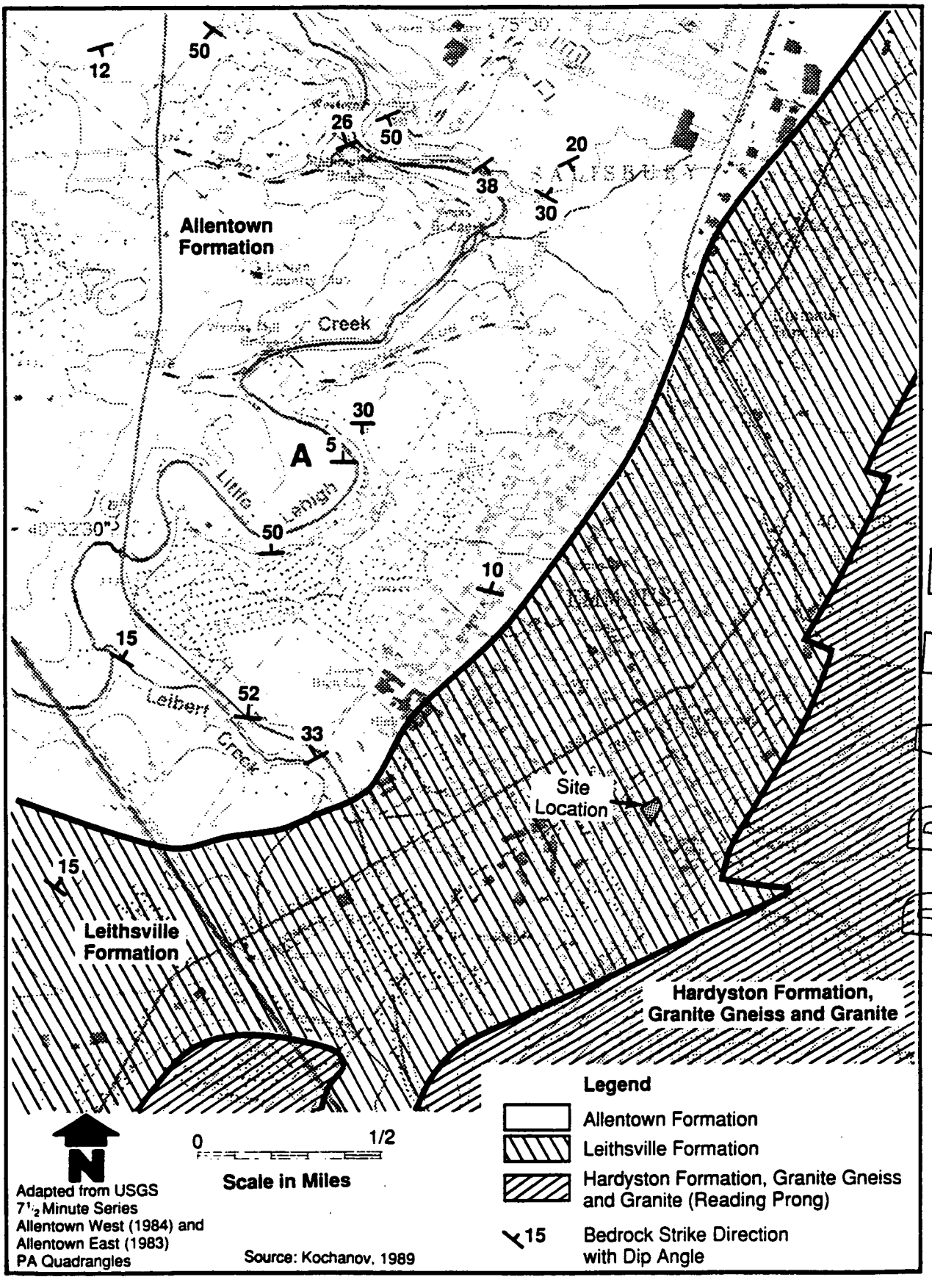

FIGURE 2-1 GEOLOGIC MAP OF EMMAUS AREA

SECTION 3

HYDROGEOLOGY

Surface Water

Surface water drainage in the site area includes Little Lehigh Creek and two of its tributaries: Leibert Creek and an unnamed intermittent stream (Figure 3-1). Little Lehigh Creek, which is downslope and northwest of the site, flows to the north toward the Lehigh River. Leibert Creek, southwest of the site, flows northwesterly toward its confluence with Little Lehigh Creek and through a storm sewer outfall, has been the discharge point for the effluent from the air stripper column at the site. The unnamed intermittent stream, north of the site, flows to the northwest and discharges to Little Lehigh Creek.

Ground water is the main source of water for Little Lehigh Creek (Wood et al., 1972). When the ground water level declines in the region, the upper section of Little Lehigh Creek, west of the Pennsylvania Turnpike, become dry (Wood et al., 1972). Although, the upper sections of Little Lehigh Creek is a losing stream, the segment of the creek east of the turnpike does not usually become dry as there are several springs along the creek. These springs are ground water discharge points to the surface water and may represent an intersection of several joints or fractures in the bedrock. In areas where the springs discharge, Little Lehigh Creek is a gaining stream.

Ground Water

The contour map of ground water elevations in the site area is illustrated in Figure 3-1 (Wood et al., 1972). Results of ground water modelling for the Little Lehigh Creek Basin indicate that the direction of flow in the basin is essentially unchanged from that reported in 1972 by Wood et al., (Sloto, personal communication, 1989) (Figure 3-1). The slope of the regional water table surface indicates that ground water flow from the site area is to the northwest, in the direction of Little Lehigh Creek.

Although ground water flows in the direction of Little Lehigh Creek, and two springs are observed along the creek, most ground water never becomes part of the surface water and may actually flow under Little Lehigh Creek as suggested by the ground water level elevation contours (Figure 3-1). Therefore, contaminants moving with the ground water may also

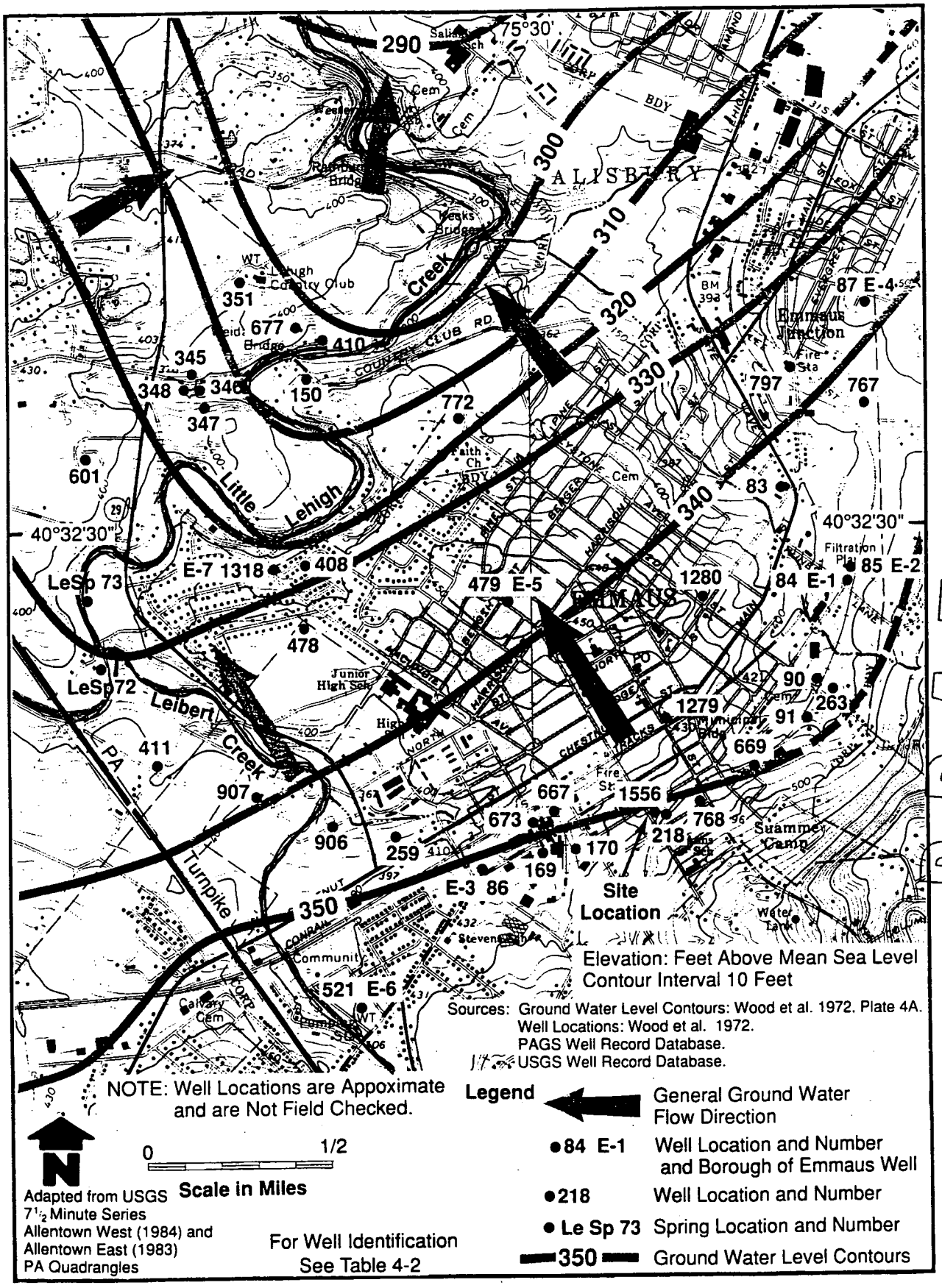

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FIGURE 3-1 GROUND WATER LEVEL CONTOUR AND WELL LOCATION MAP

flow under the creek and appear in ground water west of Little Lehigh Creek.

Geologic Effects On Water Flow Paths

Carbonate rocks are susceptible to solution and the formation of karstic features such as sinkholes which develop above cavities in carbonate rock. Karstic features typically occur along the interconnecting joints, fractures, zones of dolomitization, and bedding planes where solution causes enlargement and creates channels for the movement of ground water (Freeze and Cherry, 1979).

Ground water in the bedrock of the Allentown and Leighsville Formations primarily moves through secondary openings along joints, bedding planes and other fractures (Wood et al., 1972). Therefore, the ground water flow that generally moves toward Little Lehigh Creek but may take a circuitous route due to the solution channels in the rock. Solution channels are present in the bedrock as evidenced by the sinkhole formation in the region and the large cavity found on site in the drilling of Well No. 4 (Well No. 1556 in Figure 3-1) (SNR Company, 1989). Therefore, ground water may flow to the west along one set of channels and then flow to the north in another set in a stepwise fashion resulting in ground water flow to the northwest.

Because bedrock does not outcrop in the vicinity of the site, the orientations of fractures and joints have not been measured. Nevertheless, fracture traces have been analyzed by WESTON and findings provide evidence of the orientation of solution controlling fractures and joints as discussed in the next section. As noted previously, the general strike direction of the bedding planes is to the northeast but bedding dip directions are highly variable (R.E. Wright Assoc., 1982). The dip of the underlying bedrock formation at the site is to the southeast (SNR Company, 1989).

The effect of the joints and fracture systems on the surface water is indicated by the flow path of Little Lehigh Creek which makes abrupt high angle turns (Figure 1-1). The drainage pattern at the headwaters of Little Lehigh Creek, west of the Pennsylvania Turnipike appears to have no pattern while the drainage pattern in the area east of the turnpike near Emmaus has a very sinuous nature with high angle turns. This suggests the drainage is more joint controlled near Emmaus than at the headwaters (Figure 1-1). The stream bed near Emmaus also parallels both South Mountain and the geological contacts suggesting the orientation of the creek may be influenced by fundamental patterns in the bedrock.

Ground Water Quality

The overall water quality picture for the area is incomplete because most wells are tested only for bacteria and not for TCE or other hazardous constituents, and a number of TCE sources may exist. The offsite wells where data are available for hazardous constituents, principally TCE, are the seven Borough of Emmaus wells which have been analyzed quarterly (Borough of Emmaus, 1981-1989). Based on the present data, the TCE concentrations are highest at the site (SNR Company, 1989).

The ranking of the wells from the highest to the lowest average TCE concentrations is: Well Nos. 5, 7, 1, 2, 4, 3, and 6. The highest ranking of the average TCE concentrations in wells is as follows:

- Well No. 5 TCE concentrations are generally an order of magnitude higher than TCE concentrations in Well No. 7.
- Well No. 7 TCE concentrations are generally an order of magnitude higher than TCE concentrations in Well Nos. 1, 2, and 4.
- Well Nos. 1, 2, and 4 TCE concentrations are generally an order of magnitude higher than TCE concentrations in Well No. 3.
- Well No. 6 generally has no TCE detected.

Since 1982 all borough wells, except Well Nos. 3 and 6, have usually exceeded the EPA maximum contaminant level of 5 ppb for TCE (Table 3-1).

Because of the TCE concentrations, the Borough of Emmaus closed and abandoned Well No. 5 in December 1988 (DeLong, personal communications, 1989). In addition, the borough has issued public announcements about the TCE levels in Well No. 7 as required by Pennsylvania Department of Environmental Resources (PA DER) regulations when a compound, averaged over the previous four consecutive quarters, exceeds the level specified in the PA DER regulations. In 1988, the average TCE concentration, after chlorination of the water of Well No. 7 was 7.78 ppb (Fosselman, 1989). When averaged over the previous four consecutive quarters in 1988, all of the other borough well waters, after chlorination, were below the 5 ppb limit.

Table 3-1

Borough of Emmaus Well Water TCE Concentrations (in ppb) 1983-1987

	Well Numbers						
Date	#1	#2	#3	#4	#5	#6	#7
2/24/83	7.0	9.0	6.2	6.3	208.0	0.3	32.9
5/23/83	5.8	-	2.0	5.2	155.0	<0.1	25.7
8/5/83	6.3	4.9	1.5	4.5	175.4	<0.1	28.0
11/15/83	9.9	19.1	6.5	9.8	203.0	<0.1	35.9
2/16/84	13.8	10.7	3.2	11.3	196.0	3.7	39.0
5/14/84	<5.0	<5.0	<5.0	<5.0	129.0	<5.0	29.0
8/17/84	4.4	5.2	1.6	2.9	154.0	-	33.1
11/26/84	7.3	9.3	4.5	2.1	127.0	0.9	29.3
2/26/85	9.4	12.0	<0.1	1.5	117.0	1.7	25.2
5/16/85	10.1	9.7	2.3	6.6	184.1	<0.1	60.1
8/26/85	10.9	10.9	5.8	9.0	30.5	3.6	21.8
11/25/85	14.9	8.9	2.8	6.2	63.8	<1.0	32.5
2/24/86	11.7	7.1	2.4	6.4	17.3	<1.0	35.4
5/27/86	17.7	13.2	4.0	9.0	-	4.2	210.2
8/15/86	29.2	21.0	<1.9	12.6	401.0	<1.9	97.8
11/19/86	9.5	6.6	<1.9	3.6	105.0	<1.9	17.9
2/24/87	6.0	4.8	<1.9	5.2	120.0	<1.9	28.6
5/28/87	3.6	3.4	<1.9	2.8	18.0	<1.9	28.8
8/14/87	7.4	5.6	2.4	4.4	102.0	<1.9	37.0
11/18/87	6	5	<3	4	83	<3	28
Average	9.8	9.0	3.0	5.9	136.3	1.8	43.8

Source of raw data: Borough of Emmaus Water Quality (Organics) Data 1981-1989

- : No data

Ground Water Quality Trends

The Borough of Emmaus water quality data were grouped by each well and then by each year to determine if there might be seasonal fluctuations in the TCE concentrations (Table 3-2). TCE has been found in all borough wells. The highest TCE concentrations are usually associated with samples collected in February of each year. This highest concentration corresponds with the late winter period when a significant amount of water is added to the ground water system due to the lower evapotranspiration (Wood et al., 1972). This seasonal increase in ground water may act as a flushing mechanism that causes the TCE concentrations to be higher in the February sampling.

In an attempt to "smooth" the graph of the TCE concentration versus sampling date, and assess the long term trends, a four quarter moving average was calculated and plotted for three selected Borough of Emmaus Wells, Nos. 1, 5, and 7 (Table 3-3 and Figure 3-2). These wells were selected because they had the highest reported TCE concentrations among the borough wells, were distributed across the borough, and had the fewest not detected values which are difficult to account for in performing the calculations. Four consecutive quarters were averaged to minimize the effects of seasonality and to be consistent with calculations required of the Borough by PA DER. Only data from 1983 to 1987 were used for this discussion because sampling became standardized to the same months (February, May, August and November) every year in 1983 and the reported water quality data are for treated water rather than raw water after November 1987.

In calculating the moving averages, two situations required different averaging methods. In the first situation, one of Well No. 1's sampling results, (May 1984), was a "less than value" (<5.0 ppb). To account for this, the detection limit value (5.0 ppb) was assigned as the reported concentration. This procedure biases the calculated moving average to be slightly higher than the actual moving average would be as the actual concentration, if any, would have been less than 5 ppb. The second situation involves no sampling results reported for Well No. 5 during May 1986. For moving averages requiring the May 1986 result, only three samples were averaged to keep the Well No. 5 averages and graphs consistent with Wells No. 1 and 7.

The most noticeable trend in Figure 3-2 is the decline in TCE concentrations in Well No. 5 between February 1983 and August 1985. This decline may represent the termination of pumping at Well No. 5 in 1981 (DeLong, personal communication, 1989).

Table 3-2

Number of Years the Highest TCE Concentrations Occurred During a Particular Month

Borough of Emmaus Well No.	Month			
	February	May	August	November
1	2	0	2	2
2	3	0	2	1
3	1	1	1	2
4	3	0	2	1
5	4	2	0	0
6	3	1	1	0
7	2	2	1	1
Totals	20	6	9	7

Source of raw data: Borough of Emmaus Water Quality Data (Organics), 1981-1989.

Note: Table reflects only the data between 1982 and 1988 when the sampling period became standardized to February, May, August and November sampling periods, and samples were collected from untreated water. Beginning in 1988, the reported water quality data are for treated water and cannot be used for this analysis.

Table 3-3

Moving Averages for TCE Concentrations (in ppb) in the Untreated Water From Selected Borough Wells

First Quarter of the Four Quarters Averaged	Well No. 1	Well No. 5	Well No. 7
2/83	7.25	185.25	30.63
5/83	8.95	182.35	32.15
8/83	8.75 (1)	175.85	32.98
11/83	8.28 (1)	170.5	34.25
2/84	7.63 (1)	151.5	32.6
5/84	6.53 (1)	131.75	29.15
8/84	7.8	145.5	36.93
11/84	9.43	114.65	34.1
2/85	11.33	98.85	34.9
5/85	11.9	73.93	37.45
8/85	13.8	37.2 (2)	74.98
11/85	18.38	160.7 (2)	93.98
2/86	17.03	174.43 (2)	90.33
5/86	15.6	208.67 (2)	88.63
8/86	12.08	161	43.28
11/86	6.63	86.25	28.08
2/87	5.75	80.75	30.6

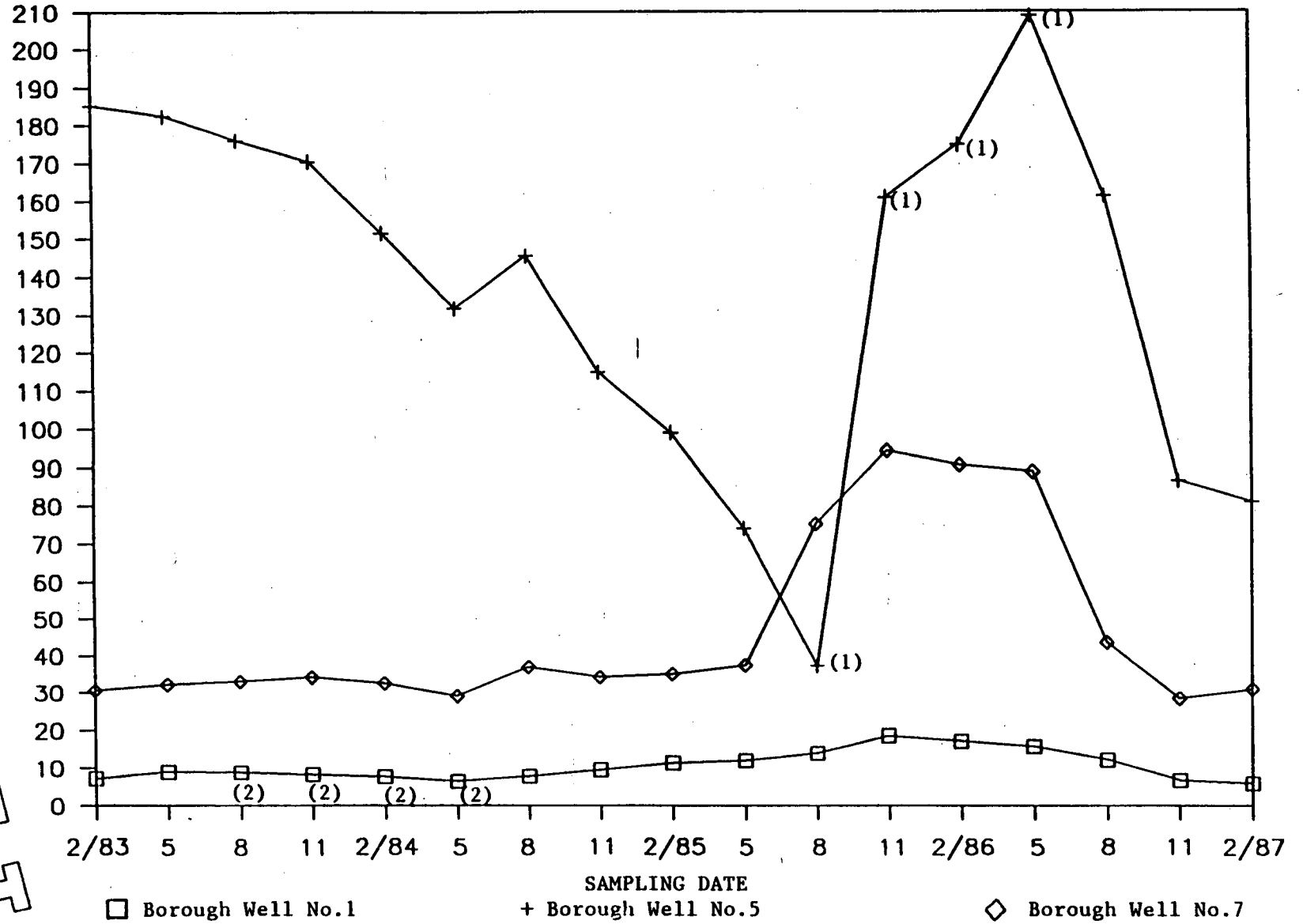
Note: Concentrations were averaged over four quarters and averages are plotted on Figure 3-2. Wells were selected because of their location and TCE concentrations.

(1) A less than value (5/84) was averaged into the calculated average. The value used for the calculation was the detection limit for that sample. Thus, the calculated moving averages using this detection limit value will be higher than the true average.

(2) Only 3 samples were averaged instead of four. No sample was collected from well No. 5 during 5/86.

Source of Raw Data: Borough of Emmaus, Water Quality Data (Organics), 1981-1989.

FIGURE 3-2
Plot of Moving Averages for TCE Concentrations
in the Untreated Water from Selected Borough Wells



Note: Data from Table 3-1

(1) Only 3 samples were averaged instead of four. No sample was collected from Well No.5 during 5/86.

(2) A less than value (5/84) was averaged into the calculated average. The value used for the calculation was the detection limit for that sample. So, the calculated moving averages using this

Because less water was being pumped in Well No. 5, the ground water containing the TCE was not being drawn toward the well.

A peak in TCE concentrations occurs in each well during the late spring and summer of 1986. The cause of this increase in TCE concentrations in all of the wells has not been determined. This increase may be real and may reflect a storm event or a change in the regional pumping patterns (among other possible scenarios) causing some TCE to be flushed through the system.

Based on the Borough's water quality data (Table 3-1) and the ground water level contour map (Figure 3-1), the TCE plume appears to be generally moving north-northwest to northwest towards the Borough of Emmaus Well Nos. 5 and 7 (Table 3-1; Figure 3-1). Some anomalies were also noted. If the site was assumed to be the only TCE source in the area, then Well No. 6, which is upgradient of the site, should contain no TCE. However, Well No. 6 contains a small amount of TCE suggesting other TCE sources may also exist in the area upgradient of Well No. 6 and the site. The Borough's Well No. 3 is cross gradient of the site and contains small concentrations of TCE. From these data, it is uncertain if another source exists for Well No. 3. All of the other Borough wells are downgradient of the site with various TCE concentrations.

SECTION 4

INVENTORY OF WATER DISCHARGE POINTS AND WATER SUPPLY WELLS

Discharge Points

During field reconnaissance performed by WESTON along Little Lehigh Creek, the only obvious ground water discharge points observed were the two previously mentioned springs in the area. The most important spring, Le Sp-73, was downgradient of the site (Figure 3-1) (Wood et al., 1972). Based on the ground water level elevation map, Le Sp-73 is not in a direct ground water flow path. This spring may provide a convenient monitor point for the ground water system.

Water Supply Wells

Many years ago, water for area residents and businesses was supplied from individual private wells. Today, most of the water is supplied through a public water system (Figure 4-1). Water for the Borough of Emmaus is supplied by six wells. A summary of the available information for the Borough wells, such as well depth and average daily flow is shown in Table 4-1. Some areas, to the northwest of the site, are apparently outside the coverage of the public water systems. In these outlying areas, water is assumed to be supplied by private wells as shown in Figure 4-1. Some of the areas that are currently being served by the public water systems may have active wells; there is no documentation of which homes or industries are using the well water (DeLong, Personal Communication, 1989).

The largest water user in the area is the Borough of Emmaus Public Water System (Delaware River Basin Commission, 1989). The 1988 average daily pumpage was approximately 1.3 million gallons. The annual pumpage is approximately 500 million gallons. Well Nos. 1, 2 and 6 provide approximately 70 percent of the total pumpage.

The next largest user in the area is the Lehigh Country Club which pumped water at a rate of 170,000 gpd in the summer of 1988 (Delaware River Basin Commission, 1989). The country club uses this water on a seasonal basis primarily for irrigation.

Other wells in the area were identified during a literature review of the U.S. Geologic Survey (USGS) and Pennsylvania Geologic Survey (PAGS) files and reports. These well

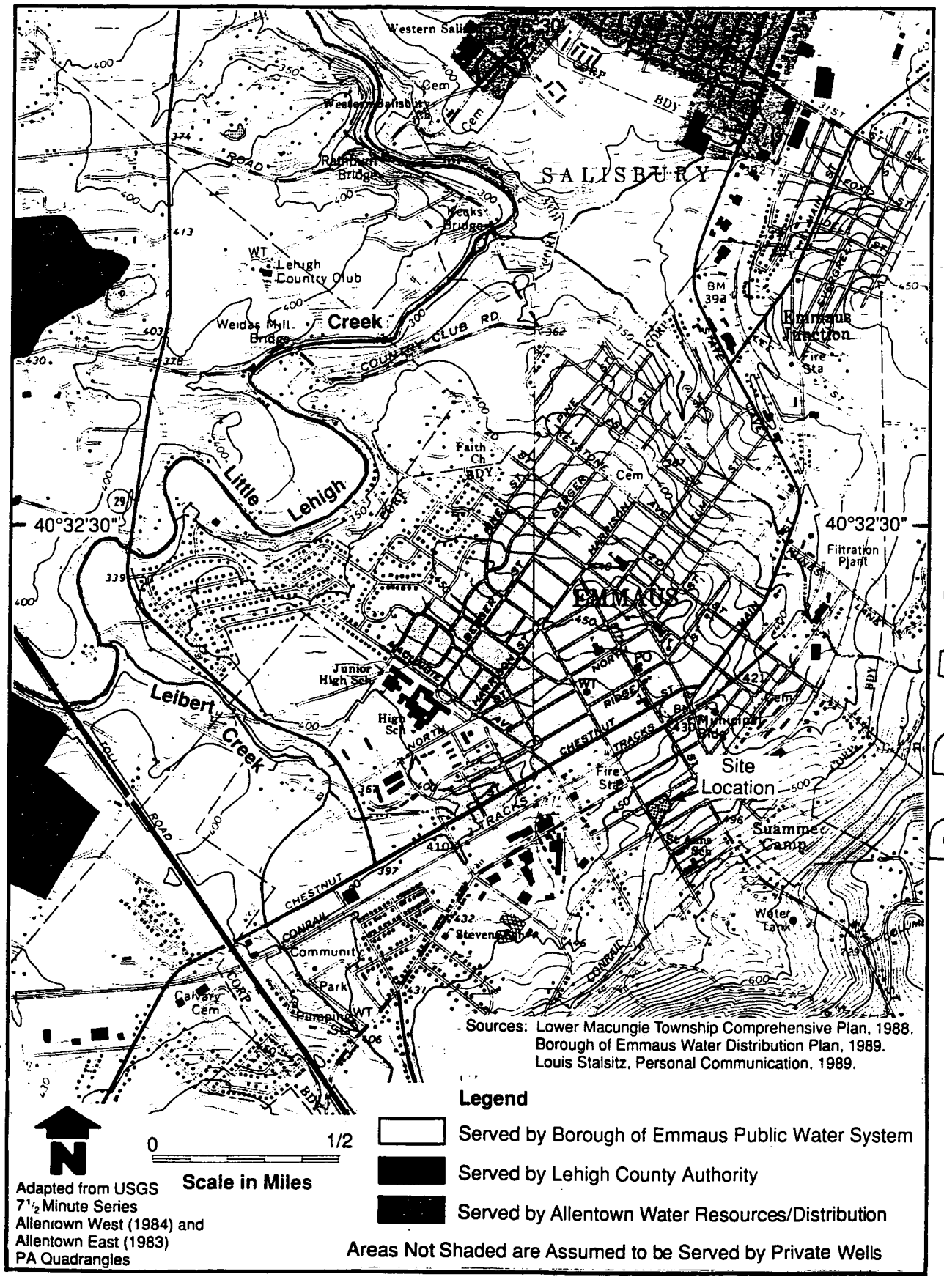


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FIGURE 4-1 AREAS SERVED BY PUBLIC WATER SYSTEMS

Table 4-1

Summary of Parameters for the
Borough of Emmaus Water Wells

Well Number	Casing Diameter (in)	Well Depth From Ground Surface (ft)	Ground Surface Elevation (ft)	Pump Capacity (gpm)	Average 1988 Daily Flow[1] (gpd)
1	10	315	422	450	244,369
2	10	385	422	475	233,146
3	10	526	410	450	123,893
4	10	183	462	350	175,474
5 (2)	--	462	458	--	--
6	10	358	400	580	459,901
7	10	400	360	550	119,773

(1) Source: Borough of Emmaus 1988 Water Production Data.

(2) Source of well No. 5 data: Wood et. al., 1972. Well No. 5 was abandoned in 1988 (DeLong, persona communications, 1989).

-- No data.

Source: Water Distribution System, Fire Hydrants and Fire Alarm Boxes in the Borough of Emmaus, Lehigh County, Pennsylvania. Revised March 17, 1989.

locations are shown in Figure 3-1 and the well owners and specifications, where known, are identified in Table 4-2. Without a field check, it is impossible to determine which of the wells on this dated list are currently in use. It should be noted that small differences in elevations and well depths for the Borough's wells exist between Table 4-1 and 4-2. The numbers listed on the tables are in accordance with the sources noted on each table. No attempt has been made as part of this assessment to rectify the differences. As a matter of comparision, the diferences, where they exist, are generally small (e.g., less than 10 feet) and on a regional basis any said differences are inconsequential.

To date, only the Borough of Emmaus wells are on record as being tested for organic compounds in the water. PA DER sampled some residential wells in the area not serviced by public water in the spring of 1989. Because of PA DER laboratory difficulties, no results were available. These same wells are scheduled to be resampled on 15 November 1989. This action was taken because these homes are in the vicinity of Borough Well No. 7 where elevated TCE concentrations have been detected on a regular basis (Table 3-1).

Table 4-2

Well Records for Area Downgradient of the Site

Well No.	Owner	Year Completed	Ground Surface Elevation (ft)	Depth of Well (ft)	Comments	Source (a)
51a	Borough of Emmaus	--	--	260	Not located, only listed in a table in source	1
51b	Borough of Emmaus	--	--	325	Not located, only listed in a table in source	1
52	H. Kostenbader Brewing Co.	--	--	270	Not located, only listed in a table in source	1
53	Emmaus Silk Co.	--	--	125	Not located, only listed in a table in source	1
83	Emmaus Auto Parts	1928	375	125	Not located, only listed in a table in source	2
84	Emmaus Borough	1923	425	311	E-1, Borough of Emmaus Well No. 1	2
85	Emmaus Borough	1923	425	375	E-2, Borough of Emmaus Well No. 2	2
86	Emmaus Borough	1949	410	525	E-3, Borough of Emmaus Well No. 3	2
87	Emmaus Borough	1951	465	187	E-4, Borough of Emmaus Well No. 4	2
90	(b) [redacted]	--	430	260		2
91	(6) [redacted]	1910	430	325		2
150	---	--	--	--	Only on well location map	3
169	Lloyd A. Fry Roofing Co.	1907	430	251	Owens Corning Felt Co.	2
170	Lloyd A. Fry Roofing Co.	1899	435	227	Owens Corning Felt Co.	2
218	Rodale Mfg. Co.	--	460	330		2
259	---	--	--	--	Only on well location map	3
263	---	--	--	--	Only on well location map	3
345	Brookhaven Sales	1975	--	102		3
346	(b) [redacted]	[redacted]	--	137		3
347	(6) [redacted]	[redacted]	--	102		3
348	[redacted]	[redacted]	--	227		3
351	[redacted]	[redacted]	--	75		3
408	---	--	--	--	Only on well location map	3
410	[redacted]	[redacted]	315	145		2
411	[redacted]	[redacted]	410	145		2
478	[redacted]	[redacted]	400	91		2
479	[redacted]	[redacted]	458	462	E-5 Borough of Emmaus Well No. 5	2
521	[redacted]	[redacted]	400	350	E-6 Borough of Emmaus Well No. 6	2

Table 4-2 (cont'd)

Well Records for Area Downgradient of the Site

Well No.	Owner	Year Completed	Ground Surface Elevation (ft)	Depth of Well (ft)	Comments	Source (a)
601	(b) (6)	1961	425	300		2
667	Air Products & Chem., Inc.	1957	430	250		2
669	Emmaus Foundry & Mach. Co.	--	470	216		2
673	Air Products & Chem. Inc.	1956	430	200		2
677	Lehigh Country Club	1955	315	125		2
767	(b) (6)	--	--	110		3
768		--	--	130		3
772		--	--	237		3
797		1965	420	175		2
906		1948	365	132		2
907		1967	390	192		2
1279	--	1910	450	270		4
1280	--	1915	460	125		4
1318	Borough of Emmaus	1973	370	400	E-7, Borough of Emmaus Well No. 7	4
1556	Square D Company	1981	--	342	Well Number 4	3
Springs						
Le Sp-72		--	--	--	Only on well location map	2
Le Sp-73	Camp Olympic, Inc.	--	325	--	400 gpm discharge	2

(a) Sources: 1 Ground Water in Southeastern Pennsylvania, PAGS Water Resource Report 2, 1934.
2 Water Resources of Lehigh County, Pennsylvania, PAGS Water Resource Report 31, 1972.
3 PAGS Well Record Database.
4 USGS Well Record Database.

-- Data Unavailable

Well numbers are keyed to locations shown on Figure 3-1.

Note: Some data for the Borough of Emmaus wells are inconsistent on this table compared to Table 4-1. The different sources of the data are apparently using different references. Table 4-1 is assumed to contain the correct data because the borough supplied the data for their own wells.

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SECTION 5

REVIEW OF HISTORICAL AERIAL PHOTOGRAPHS

Aerial photographs taken in 1939, 1946, 1964, and 1974 (Appendix A) were obtained from the National Archives, the U.S. Department of Commerce, and the Pennsylvania Department of Transportation. The goal of the photographic review was to identify operational history of the site, past waste disposal practices, and other industrial activities in the area.

The small size of the site and the scale of the photographs prohibited any significant determination of the operational history or past waste disposal practices on site. The industrial activities in the area apparently have not changed much over the years. Most of the large industrial buildings present in the 1939 photographs are still standing today. The Borough has grown northwest toward the Little Lehigh Creek. The largest growth occurred after the 1964 photograph.

The 1939 photographs show two areas of land disturbances that are not apparent on the subsequent photographs. One area is near Sixth and Harrison Streets. Because of the small scale and the quality of the photographs, it is unclear what activity occurred at this location; it may have been an old brick operation that existed in this area (Reiss, personal communications, 1989).

The other area located to the east of the intersection of Tenth and Broad Streets appears to have been a quarry that was subsequently filled. Currently, several industries are located in this area. The fill material is unknown.

SECTION 6

FRACTURE TRACE ANALYSIS

Fracture traces are "...natural linear features consisting of topographic (including straight stream segments), vegetation, or soil tonal alignments, visible primarily on aerial photographs and expressed continuously for less than one mile." (Lattman, 1958). Fracture traces are considered surface expressions of vertical or near vertical zones of fracture concentration (Parizek, 1976). The significance of the fracture traces is similar to that of the previously mentioned joints in determining ground water flow. If the fracture traces are expressions of zones of higher fracture concentrations, then the fracture traces would be considered ideal candidates to have increased flow along their length. The increased flow would result from the greater permeability and in turn would promote dissolution of the carbonate rocks (Freeze and Cherry, 1979).

Using the aerial photographs (described in Section 5), a fracture trace survey was performed. The aerial photographs were obtained to span a period of years (1939 to 1974) so that fracture traces could be identified. The most recent aerial photographs show the urbanization that has occurred since World War II. Because urbanization tends to obscure natural features, such as fracture traces, photographs prior to the urbanization are necessary. Furthermore, photographs taken at different seasons allow seasonal effects to be identified.

A study of the Middle Delware River Basin performed for the Delaware River Basin Commission by R.E. Wright Associates, Inc. included a fracture trace analysis of Little Lehigh Creek Basin (Figure 6-1) (R.E. Wright Assoc., 1982). That study has been modified by WESTON for this project. Fracture traces observed in aerial photographs of the area obtained by WESTON (Appendix A), but not identified in the R.E. Wright Associates study, were added to the R.E. Wright Associates study. The additional fracture traces may be the result of a different observer identifying the traces or different photographs being used. None of the fracture traces have been field checked to confirm their existence.

As seen in Figure 6-1, the Borough of Emmaus has fewer fracture traces than the surrounding area. This is the result of the urbanization obscuring features that may have been present under the natural condition prior to urbanization.

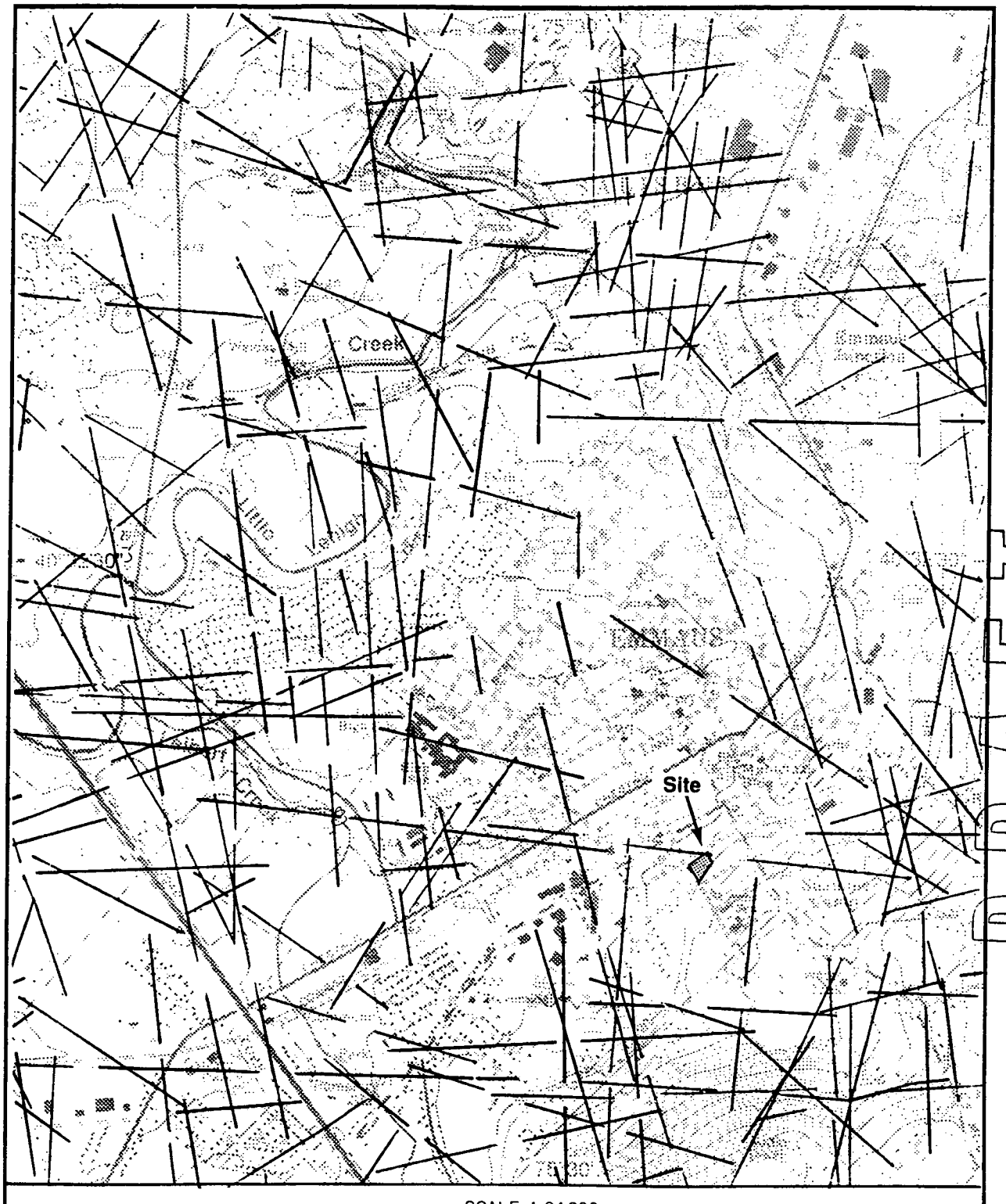

FIGURE 6-1 FRACTURE TRACE ANALYSIS FOR SITE AREA, EMMAUS, PA

Using the orientations of the identified fracture traces within a mile of the site, a rose diagram was constructed to identify preferred fracture directions (Figure 6-2). The orientation of the fracture traces were measured and totaled for each 10° ~~are~~ arc of the circle. The total number of fracture traces for each arc is represented by the distance the shading radiates from the center of the circle (see Figure 6-2). Two general sets of fracture traces appear to be dominant. One set trends north-south and other east-west. These sets are probably related to the joint sets that are perpendicular and parallel to bedding (R.E. Wright Assoc., 1982).

One fracture trace projects through the site (Figure 6-1). This fracture trace may represent an area of higher fracture concentration that would be important in determining preferred ground water flow directions from the site. This fracture trace needs to be confirmed by field checking, but because of the urbanization in the area, may not be possible. If additional monitor wells are to be installed in the area, an effort should be made to locate some of the wells along this fracture trace because the fracture trace may have greater permeability than the surrounding area.

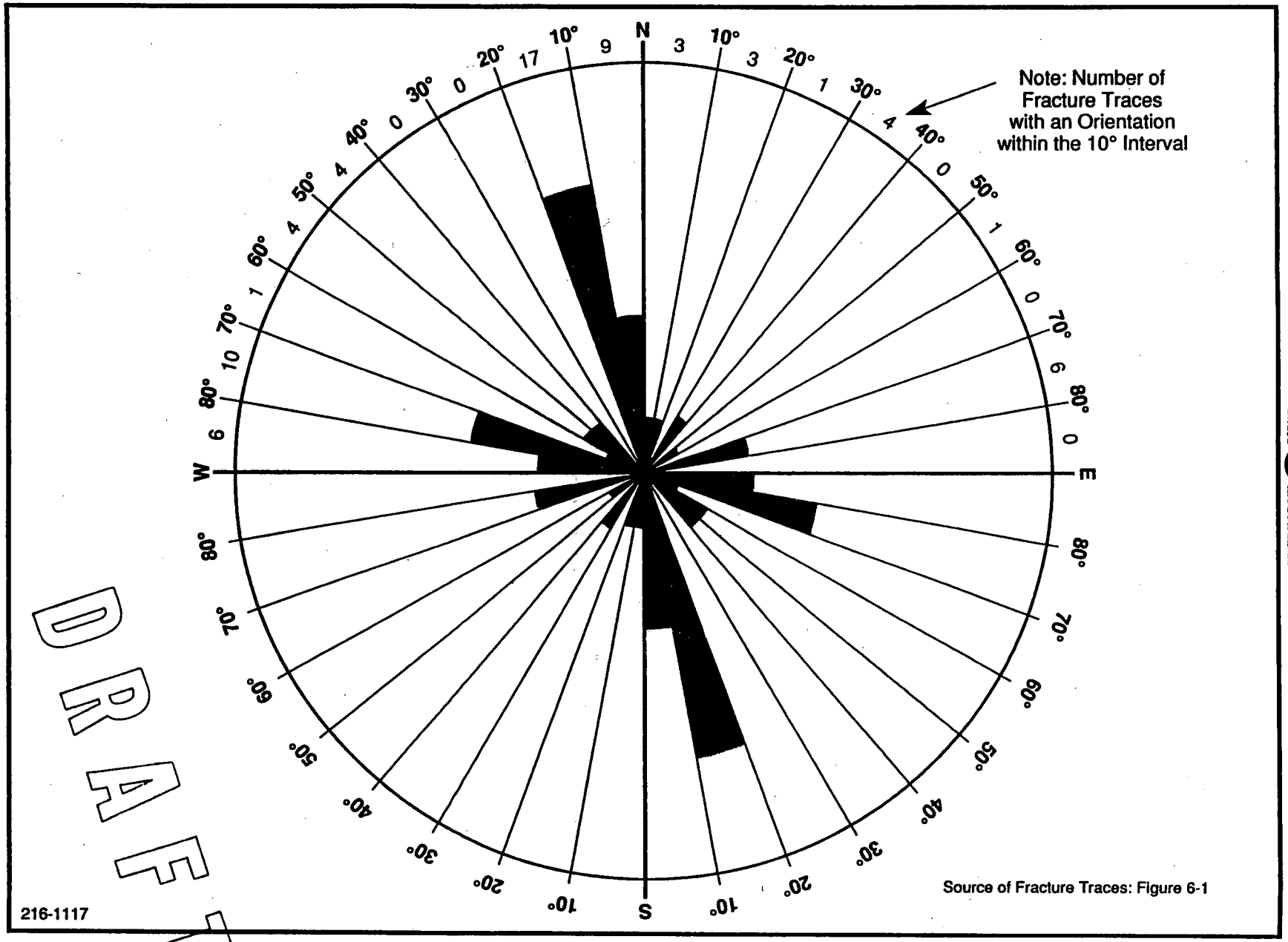

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FIGURE 6-2 ROSE DIAGRAM OF FRACTURE TRACE ORIENTATION WITHIN A MILE OF THE SITE

SECTION 7

OTHER POTENTIAL HAZARDOUS WASTE SOURCES

Several other sources of data were obtained to identify other potential TCE sources in the area. These data included:

- CERCLA (Superfund) list
- Pennsylvania Hazardous Waste Generators List
- SNR Ground Water Monitoring Plan for the site
- PA DER files for the Borough of Emmaus

Some of the other potential waste sources in the Emmaus area are shown on Figure 7-1.

The CERCLA list indicates sites currently on or under consideration for inclusion on the Superfund list. None of the sites to be discussed are designated as Superfund sites. The CERCLA list includes the company name, but contains no other information such as the contamination was not provided. The CERCLA list identified Rodale as having the same address as the Square D Company. Also identifed on the CERCLA list was the Volney Felt Company (Volney), in nearby Upper Milford Township.

The PA DER files also mentions Volney at 728 Broad Street several times. The company had a 20,000 gallon spill of #6 fuel oil in February 1974. The other correspondence in the PA DER file dealt with a disposal area operated by Volney. The company disposed of felt production waste (e.g., mostly rags and cloth) on approximately 1 acre of woodland at the end of South 7th Street. This disposal area was examined by the State Regional Sanitary Engineer in 1970 and deemed not a problem. The Volney facility may now be occupied by Owens Corning Felt which was reported in the SNR report to have 66 ppb of TCE in their well (SNR Company, 1989). This Volney facility is cross gradient, at approximately the same ground water elevation as the site suggesting the site is probably not the source of the contamination at the Volney facility.

The Pennsylvania Hazardous Waste Generators List identified the following companies in the Emmaus area:

- Air Products and Chemicals, Inc.
  733 Broad Street

- Buckeye Pipeline Company
  P.O. Box 368

- General Machine Company
  4th and Furnace Streets

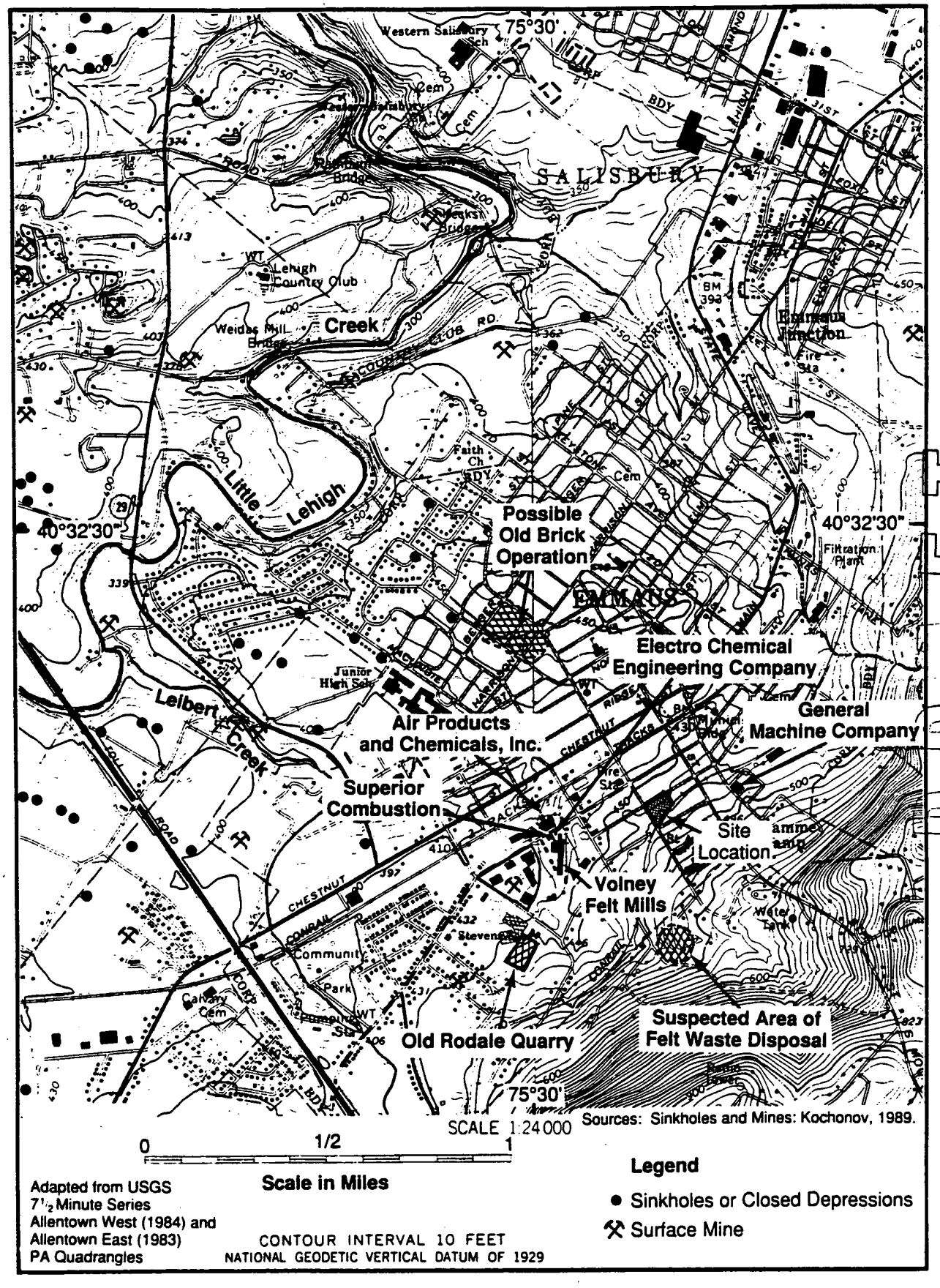

FIGURE 7-1 SOME POTENTIAL INDUSTRIAL WASTE SOURCES IN THE EMMAUS AREA

This list also identifies the compounds used in the company's processes, but not how the compounds were disposed, the quantity generated, or whether a release has occurred.

The first company listed, Air Products and Chemicals, Inc. (Air Products), has a long list of generated hazardous wastes including many of the common industrial solvents. A partial list includes: TCE; tetrachloroethylene; methylene chloride; carbon tetrachloride; 1,1,1-trichloroethane; benzene; toluene; xylene; chlorobenzene; dichlorobenzene; alcohols; and acids.

The next company listed was the Buckeye Pipeline Company (Buckeye) located west of the turnpike. Buckeye is located a considerable distance from the TCE contamination. Furthermore, TCE was not listed as one of their wastes. Therefore, Buckeye is not a probable source of TCE.

The last company listed for the Emmaus area was the General Machine Company. The company had no waste codes listed but may use TCE as a degreaser to clean machinery.

Other small hazardous waste generators, past and present, not reported in the hazardous waste generators list may exist in the area. These generators include small machine shops, dry cleaners, and auto repair shops which probably are not substantial generators of TCE. One of these small generators Uniform Rental, is mentioned in the SNR report; Uniform Rental is now believed to be Rental Uniform Services. Another possible hazardous waste generator observed during a visit to the site was the Electro Chemical Engineering Company which had drums stored on their premises on Broad Street across from Air Products. Conversations with Borough of Emmaus Fire Company Chief Robert Reiss, identified Superior Combustion, as another potential hazardous waste generator. Located on the south side of Broad Street, across from Air Products, Superior Combusion existed between approximately 1947 to 1970 as a foundry that built boilers and may have used TCE.

A list of past hazardous waste generators could possibly include most of the industrial facilities in the area. Willard Wade of Gilbert Associates, Inc. wrote in a 7 October 1987 letter to Christian Beechwood of PA DER, that prior to the installation of sewers in the area, the industrial facilities used well disposal as a common waste disposal practice (PA DER, Files, 1988).

Other potential locations where hazardous waste could have come in contact with the ground water include the previously mentioned sinkholes. Sinkholes are frequently used as disposal pits; any waste placed in the pit would enter into

the ground water more quickly than any surface disposal. Old gravel pits and quarries in the area that have been filled may also be sources of contamination. There is no direct evidence that any of the sinkholes, pits or quarries in the area have been used for TCE disposal or are sources of TCE.

A quarry south of Tenth Street and Pennsylvania Avenue was used previously for disposal of some unidentified wastes both by the Borough and by Rodale. A water pollution investigation identified that water from the quarry was flowing to Furnace Dam, a pond on the north side of Tenth Street. Rodale was told to stop the water flow to Furnace Dam (PA DER Files, 1989). The quarry has been subsequently filled with material of unknown origin and at least one building has been built on the fill.

During the evaluation of the water quality data, an effort was made to identify trends in the available water quality parameters that might suggest other possible hazardous waste sources. A trend was observed involving not TCE but tetrachloroethylene. Since February 1988, the Borough of Emmaus water quality test results for unregulated organic compounds showed an average tetrachloroethylene concentration of 14 ppb in Well No. 4. Because PCE has not been detected at the Borough of Emmaus Wells No. 1 or 2 but has been detected in Well No. 4, the PCE source may exist between Well Nos. 1 and 2, and Well No. 4 (Figure 3-1).

SECTION 8

CONCLUSIONS

The site is located in a carbonate rock valley, which makes the resolution of a ground water contamination situation difficult. The ground water flow paths may be complex in this region because the dominant ground water transport route appears to be the solution cavities. In the vicinity of the site, the general ground water flow is to the northwest or north-northwest toward Little Lehigh Creek. This general flow direction probably has not changed significantly since the site came into existence.

Ground water is the primary source of water for Little Lehigh Creek. Most water supplies in the area are also derived from the ground water system; of which the Borough of Emmaus water system is the largest user. The two springs in the area represent the only definitive ground water discharge points.

TCE has been reported in each of the Borough of Emmaus wells, with Well No. 5 having the highest and Well No. 7 having the second highest concentrations. The lateral extent of the TCE plume has not been fully defined. It extends at least to the limits of the Borough of Emmaus wells and may extend beyond them, including areas west of Little Lehigh Creek. Much work remains to be done to assess the vertical extent of the TCE plume.

It is very difficult to estimate the ground water flow rate in this area using the available TCE release information because the amount and time of the releases are uncertain. Also, the carbonate rocks have a wide range of permeabilities because of the presence of solution channels. So a large range in the estimated ground water flow rates based on TCE release data would result which would yield equivocal results.

TCE is found in ground water underlying a large area of Emmaus. This condition is a result of industrial operations in the area over the last few decades. However, it is difficult to identify the exact sources of ground water contamination in Emmaus. There are probably multiple sources of which the Rodale site is probably the one with the most visibility.

SECTION 9

RECOMMENDATIONS

The extent of the TCE contamination plume needs to be better defined. To accomplish this, the following recommendations are made:

1. To assess the lateral extent of the contamination plume, ground water should be sampled from existing wells in three zones (see Figure 9-1) downgradient of the Rodale Manufacturing site. At least three sampling points within each zone should be sampled and analyzed for Hazardous Substance List (HSL) organic compounds, metals, and cyanide. These sampling points will be selected from the Borough of Emmaus wells, springs, and the Lehigh Country Club wells.

2. PA DER will be sampling certain private wells near Lehigh Creek on 15 November 1989. If possible, some samples should be split with the State and analyzed to supplement the data collected in Recommendation No. 1.

3. To assess the vertical distribution of the contamination in the bedrock aquifer near the site, it is recommended that two multi-level cluster wells be installed on or near the site. These wells will be located, if practical, on fractures that have been identified near the site (see Figure 6-1). At each cluster well location, there will be installed three individual wells close to each other with approximately 100 feet of open borehole to depths of 225, 375, and 525 feet below ground surface. These wells should then be pump tested and sampled, along with the existing monitoring wells, to assess parameters such as the vertical distribution of the contaminants, the hydraulic characteristics and interconnection of various water-bearing zones, and the zone of influence of a pumping well. Assessment of these parameters is critical to designing the ground water treatment system for the site.

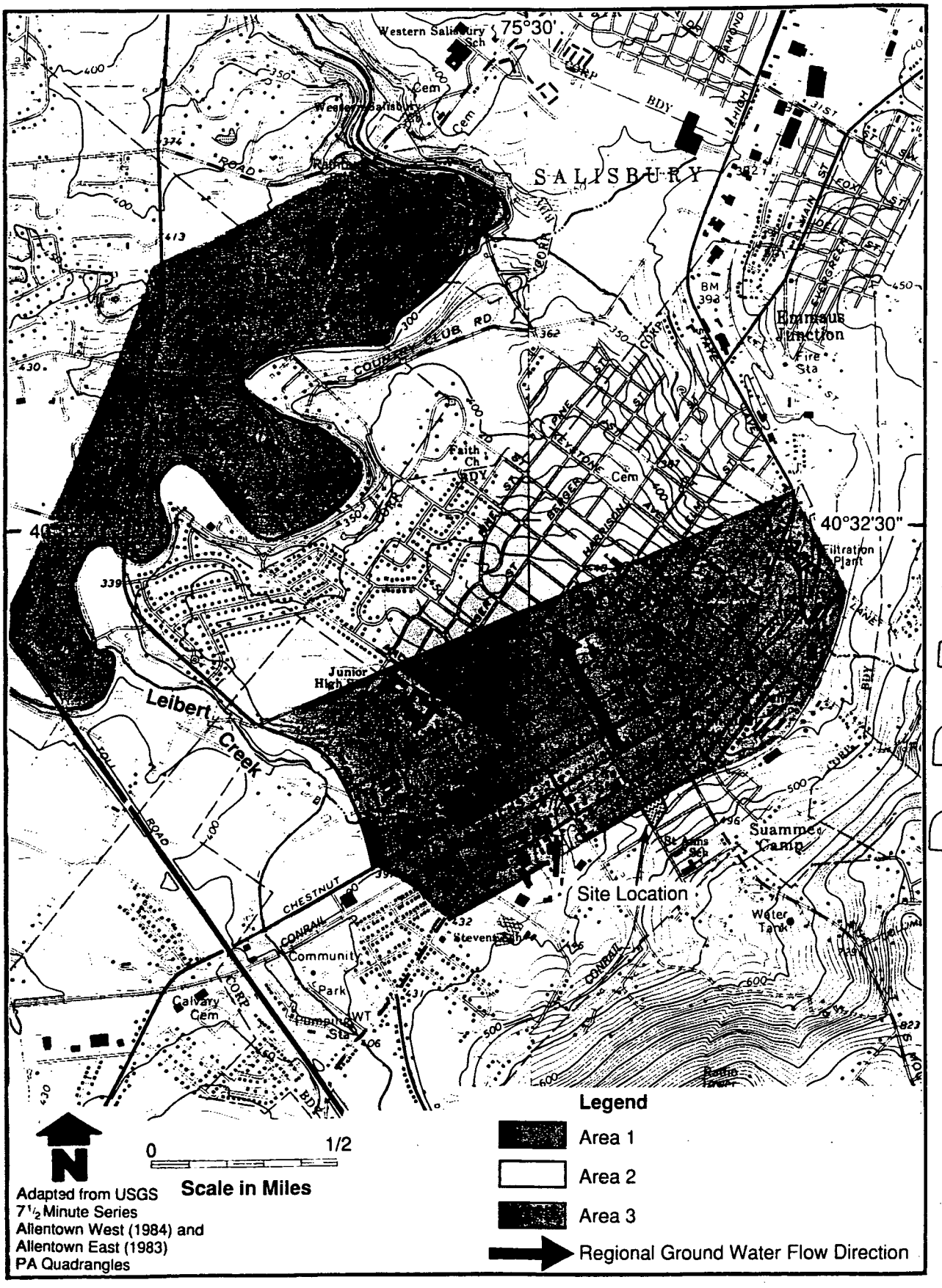

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FIGURE 9-1 SAMPLING AREA MAP

REFERENCES

Borough of Emmaus, Water Production Data 1986-1988.

Borough of Emmaus, Water Distribution Plan 1989.

Borough of Emmaus, Water Quality Data (Organics), 1981-1989.

Carey, John B. and Michael Yaworski, "Soil Survey of Lehigh County, Pennsylvania", USDA Soil Conservation Service, 1963.

Day-Lewis, Robert, Pennsylvania Department of Environmental Resources, Personal Communications, 1989

Delaware River Basin Commission, Water User Database, 1989.

DeLong, Dan, Borough of Emmaus Public Works Director, Personal Communications, 1989.

Drake, Avery, U.S. Geological Survey, Personal Communication, 1989.

Fosselman, Bruce E., Borough of Emmaus Manager, "Notice to Water Customers of the Borough of Emmaus", March 9, 1989.

Freeze, R. Allan and John A. Cherry, "Ground Water", 1979, Prentice-Hall, Inc. Englewood Cliffs, NJ.

Hall, George M., "Ground Water in Southeastern Pennsylvania," Pennsylvania Geological Survey, Bulletin W2, 1934.

Kochanov, William E., "Sinkholes and Karst-related Features of Lehigh County, Pennsylvania", Pennsylvania Bureau of Topographic and Geologic Survey, Open File Report 8701, 1989.

Lattman, L.H. "Technique of Mapping Geologic Fracture Traces and Lineaments on Aerial Photographs", Photogrammetric Engineering, 1958, v.24, no. 4, p. 568-576.

Lower Macungie Township, "Comprehensive Plan" 1988.

MacLachlan, David, Pennsylvania Geologic Survey, Personal Communication, 1989.

National Archives, Cartographic Branch, Washington D.C., Aerial Photographs, 1939.

Parizek, R.R., "Lineaments and Ground Water", Reprint from ORSER-SSEL Technical Report 2-76, Pennsylvania State University, 1976.

Pennsylvania Department of Environmental Resources, "Borough of Emmaus Industrial Work and General Government Files", 1989.

Pennsylvania Department of Environmental Resources, Bureau of Waste Management, Hazardous Waste Generator Listing, 1989.

Pennsylvania Department of Transportation, Aerial Photographs 1964, 1974.

Pennsylvania Geological Survey, Water Well Inventory, 1989.

Reiss, Robert, Borough of Emmaus Fire Chief, Personal Communication, 1989.

R.E. Wright Associates, Inc., "Special Groundwater Study of the Middle Delaware River Basin Study Area II, 1982.

Sloto, Ronald, United States Geological Survey, Personal Communication, 1989.

SNR Company, Ground Water Monitoring Plan, 1989

Stalsitz, Louis, Allentown Water Resources/Distribution, Personal Communications, 1989.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Aerial Photographs, 1946.

U.S. Environmental Protection Agency, Superfund Program List 1989.

U.S. Geological Survey, Well Database, 1989.

White, William B., "Geomorphology and Hydrology of Karst Terrains", Oxford University Press, New York, 1988.

Wood, Charles R., Herbert N. Flippo, Jr., Joseph B. Lescinsky, and James L. Barker, "Water Resources of Lehigh County, Pennsylvania", Pennsylvania Geological Survey, Water Resources Report 31, 1972.

Young, Kenneth, Environmental Planner, Lower Macungie Township, Personal Communications, 1989.

APPENDIX A

AERIAL PHOTOGRAPHS

1939 AERIAL PHOTOGRAPH

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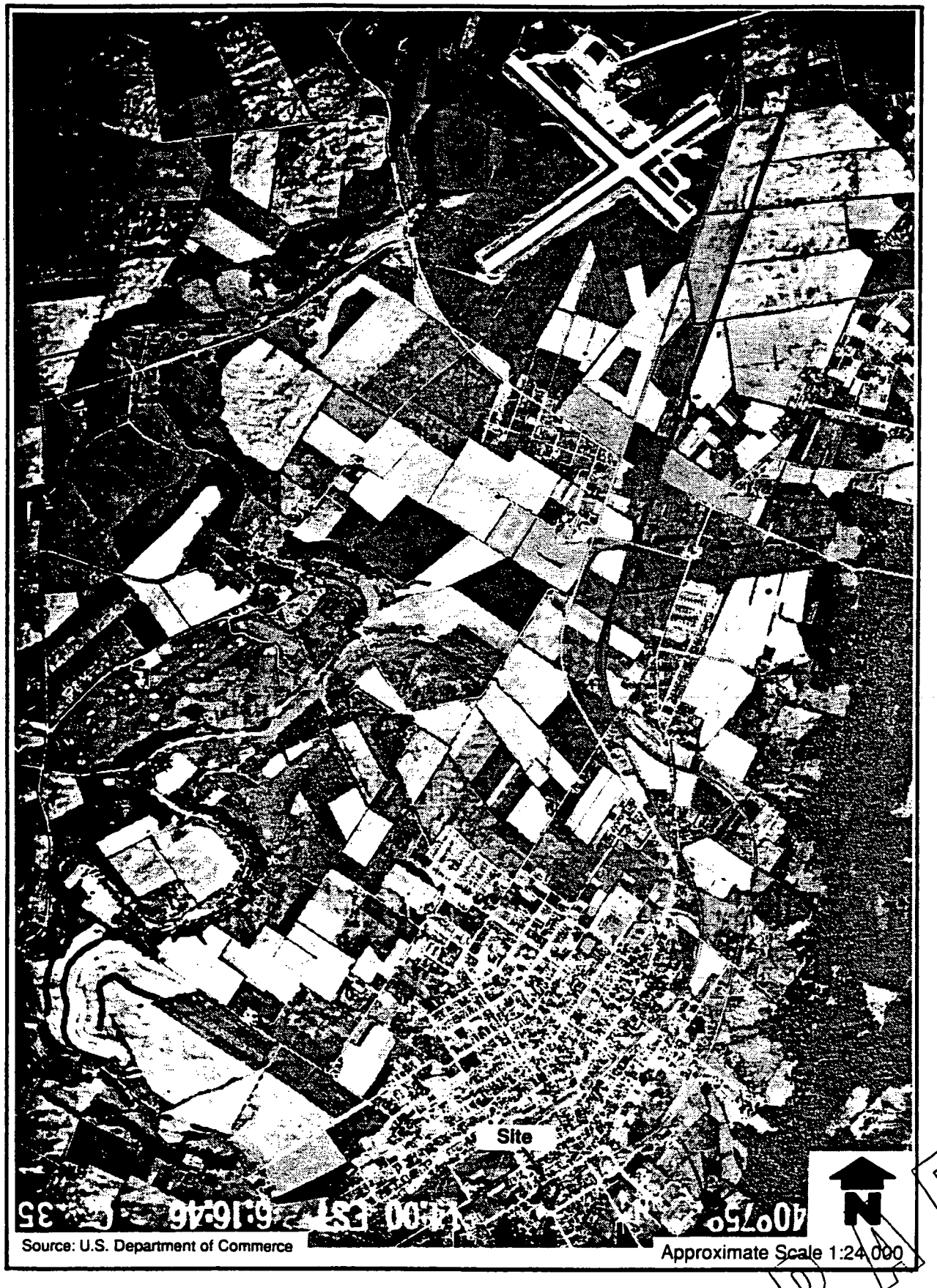
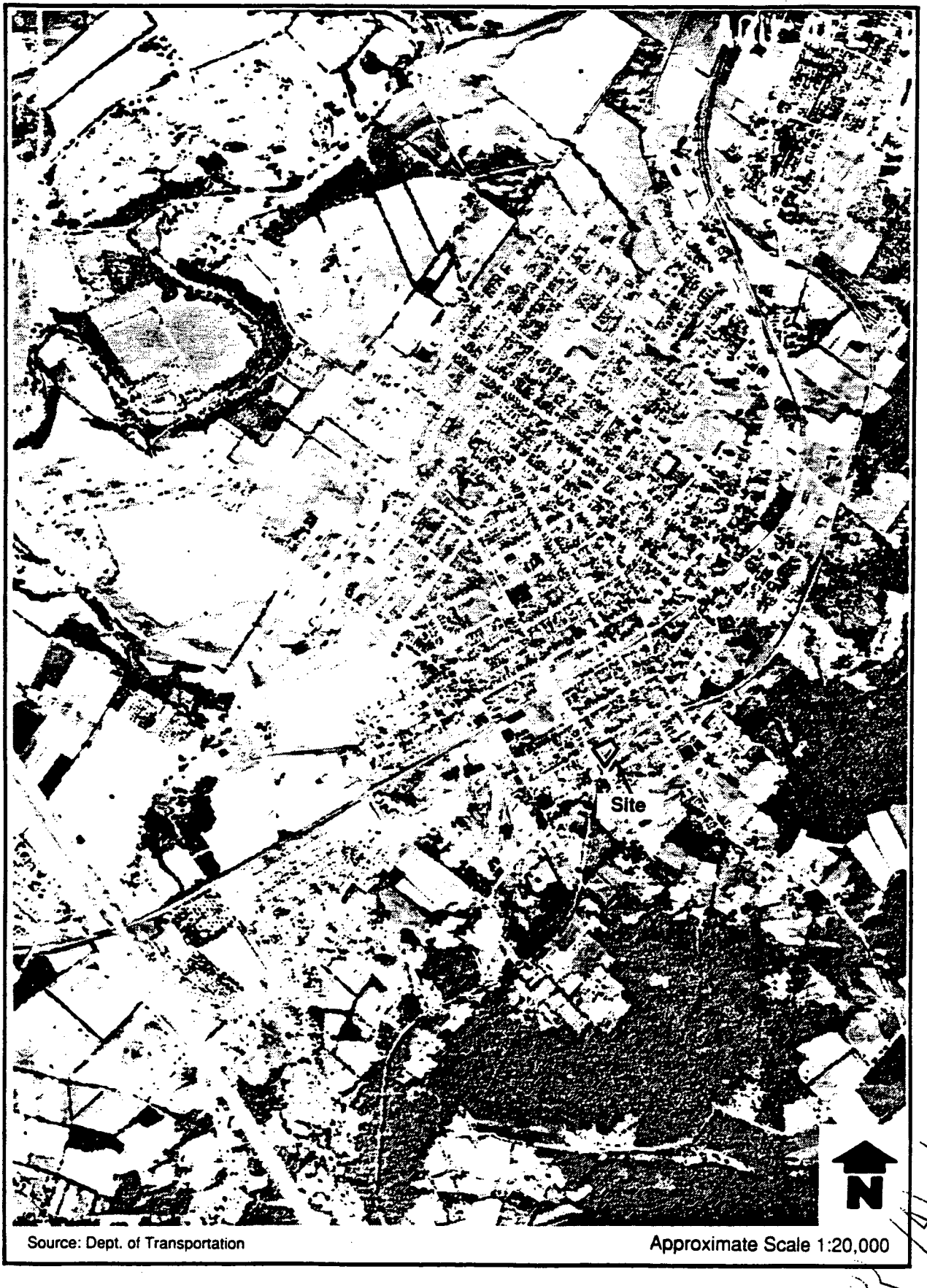


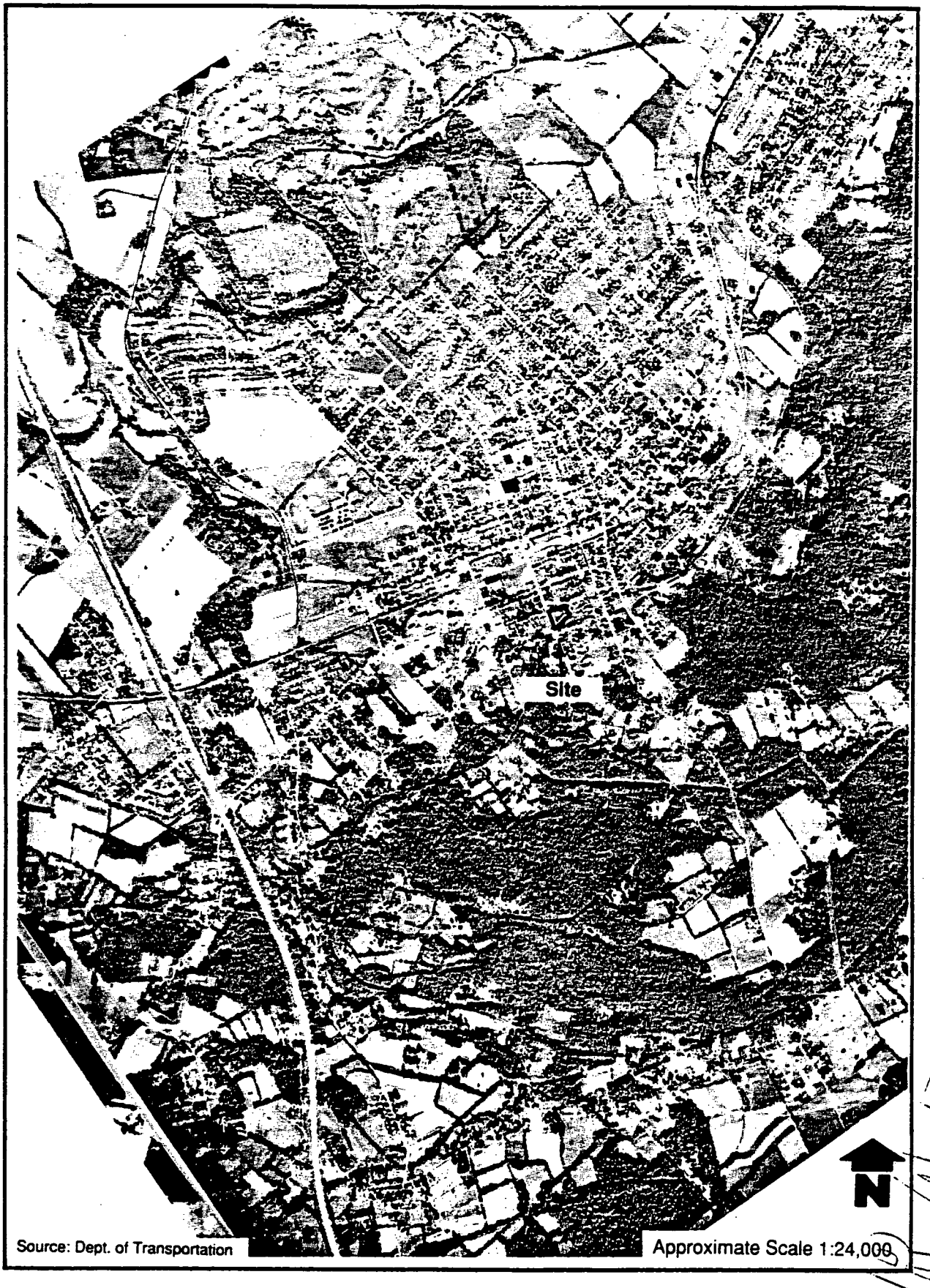
1946 AERIAL PHOTOGRAPH



Source: Dept. of Transportation

Approximate Scale 1:20,000

1964 AERIAL PHOTOGRAPH



1974 AERIAL PHOTOGRAPH

APPENDIX F
Draft Phase II Hydrogeologic Investigation Report
(Roy F. Weston, Inc., November 1989)